GEOGRAPHY AND RAINFALL OF THE NEBRASKA SANDHILLS

By BERTRAM E. HALL [1]

[Weather Bureau office, Valentine, Nebr., November 1937]

North of the Platte River in Nebraska, lies an area of approximately 20,000 square miles within which dune topography prevails; this is the sandhill region, extending from the ninety-ninth meridian on the east to the one-hundred and third meridian on the west. In the north the boundary of the area is marked roughly by the Niobrara River, from which the dunes extend southward, almost without a break, to the valley of the Platte. Some of the sandhills are no more than 25 feet high; others rise 100 feet, or even several hundred feet, above the intervening valleys. In general the hills form lines, cut by numerous basins and depressions, and run in a southeasterly direction; but in the south portion of Cherry County, near the head waters of the Loup River, there are low ranges of hills with a west to east trend. The elevation of the area above sea level varies from about 2,500 feet in the east to approximately 4,000 feet in the west.

The topography of the region is one of alternate hills and valleys dotted with marshes, lakes, lush meadows, and dry basins, many of the small depressions being filled with water. There are about 2,000 lakes, most of them very small, and none very large. The largest is "Dad's Lake," south of Valentine, approximately 5 miles in length and less than a mile wide.

The hills are of local origin. The wind was a prominent factor in the formation of the Nebraska sandhills, for the hills are the direct result of wind action upon soft, sandy bedrock and mantlerock. The numerous lakes are merely depressions scooped out by the wind and filled with water. Such shallow lakes fluctuate widely in size, and in the drier seasons many of them disappear entirely. Some, particularly in the west portion of the area, are highly alkaline, and during the World War, the recovery of potash from the lakes of the Nebraska sandhills gave rise to an active industry.

The soil is loose and sandy, and easily moved by the wind. Most of the region is more or less permanently fixed, but here and there are "blowouts" where the wind has torn away the protecting grass roots and exposed the naked sand to the elements. Such blowouts sometimes produce moving dunes, and are more numerous and of larger size in dry years than in wet years.

In spite of blowouts and small areas of drifting dunes, the sandhill region is essentially a grass region. Between the hills are moist meadow lands where grass grows luxuriantly, and on the uplands are many kinds of grasses and a variety of other plants. It is the grass that furnishes feed for literally hundreds of thousands of cattle, heals the open wounds of festering blowouts, and stops the advance of moving dunes. Numerous flowers bloom from early spring to early fall. The crocus, phlox, wild onion, pentstemons (beard-tongues) and numerous other flowers bloom in the spring and early summer. Later the man-root, a variety of morning glory, is in bloom; and in late summer the sunflower, goldenrod, asters, and blazing star brighten the landscape. The cacti are numerous, and represented by several varieties, but chiefly by the Opuntia (prickly pears) and the pin cushion cactus. Wild roses, wild plums, wild grapes, and wild cherries grow along the banks of the streams, and the yucca covers many a hillside.

In the valley of the Niobrara the Ponderosa pine covers the canyon slopes; and cottonwood, hackberry, willows, and other trees grow along the streams. Small amounts of oak and birch are found in the valley of the Niobrara, particularly east of Valentine. Farther west, in the heart of the sandhills, are two national forests, the Niobrara and the Halsey. The latter has been planted by man, and these plantings, covering about 20,000 acres, have proved that trees will grow in the sandhills if the proper varieties are planted.

The most surprising natural resource of the sandhills is the water supply: The entire region is one of light or moderate precipitation. The soil is sandy and rainfall disappears readily into it, with little surface run-off. A sandy soil heats rapidly, and summer days are often hot. Wind movement is brisk and evaporation high. Yet, in spite of these numerous adverse factors, the springs and streams of the sandhills continue to flow. Surface lakes may disappear, but the underground water supply is sufficient to maintain the sandhill rivers almost undiminished.

The sandhills have been called "the greatest reservoir of underground water in the world." Certain it is that vast quantities of water are stored underground in the Nebraska sandhills. The sand acts as an enormous sponge and drinks up rain as fast as it falls. In places the sand is 300 feet deep, and water-filled all the way down. The statement has been made by Dr. Condra of the University of Nebraska that the sandhills have absorbed one-third of their volume in water. This would mean that in an area where the sand is 300 feet deep there would be about 100 feet of water. This is equivalent to 65 years of annual rainfall at Valentine, located on the northern edge of the sandhills.

The Niobrara River rises in Wyoming and flows eastward, skirting the northern edge of the sandhills. The upper portion of its valley is shallow, but farther east in Cherry County the valley assumes canyon proportions. In Western Nebraska, as in other semiarid regions, streams are intermittent; that is, they disappear during the dry season. The upper Niobrara is no exception, but farther downstream in the deeper portions of its canyon the river has cut down below the level of springs, and become a permanent stream. From Valentine eastward, numerous springs flow into the river and its tributaries are likewise spring-fed. The significant fact is not that the river is springfed, but that the springs have continued to flow during the severe drought years. Many of these springs come from such great depths that they do not freeze even though the air temperature is 20° below zero. In 1934, 1936, and again in 1937 the top soil became so dry that it seemed as if no water could possibly be left anywhere in the soil, but the sandhill rivers continued to flow. In brief, these rivers are made possible by the unsurpassed capacity of the sandhills to store water.

Another such river is the Loup, a typical river of the sandhills. It is actually a system of rivers including the North, Middle and South Loup Rivers, the Cedar River, and Beaver Creek. These five streams all rise in the sandhills, flow southeastward and finally unite as one river which eventually flows into the Platte. The Loup rivers are fed by hundreds of springs in the sandhills; and no matter whether the season is winter or summer, or whether rain falls or not, the volume of water in the Loup changes but little. The visitor who is accustomed

[1] Deceased December 31, 1937.

to seeing rivers dry up during periods of rainless weather cannot but marvel that the sandhills can send forth so much water during periods in which they receive almost none. The secret lies in the ability of the sandhills to absorb and hold water for perhaps several hundred years.

In spite of the vast underground water supply, the surface-water level can and does decline greatly during periods of prolonged drought. The Experimental Farm maintained by the University of Nebraska at Valentine has taken water level readings in seven sandhills meadows several times a year, more or less regularly since 1922. In general, the period from March to June is the period of highest water level, and October is usually the lowest.

In 1934 there was an alarming drop in the water level for all seasons. There were those who said that it would take years for the grass to come back; but the spring of 1935 was wet, the water level climbed upward, and ranchers harvested one of the largest hay crops in the history of white settlement in the sandhills. Again in 1936 and 1937 the level of the surface water dropped discouragingly low. By September 1937 it was the lowest since records had been kept, and many of the smaller surface lakes had disappeared; but the springs and rivers continued to flow, and those who know the sandhills know that even a brief period of above normal precipitation can quickly restore the fallen water level.

Two other rivers should also be mentioned. One is the Snake, a tributary of the Niobrara and resembling the latter in many ways. About 25 miles southwest of Valentine the river has cut deep into the mantlerock and formed the beautiful Snake River Falls. Farther east is the Elkhorn, rising on the eastern edge of the sandhills; it resembles the Loup, but for much of its length it is without the sandhills and is much more likely to rise and fall than the typical sandhill rivers.

The western edge of the sandhill area, where the sandhills come in contact with the "hard lands," may receive some underground water from the Rocky Mountains; but the total amount of such water must be comparatively small.

Precipitation in the sandhills area is typical of the Plains region as a whole. Fall and winter are dry, followed by a precipitation maximum in spring and early summer. Records at Valentine indicate that 60 percent of the annual precipitation falls between April 15 and August 15. Seasonal percentages at Valentine may be considered as typical of the entire area, and are as follows:

Winter (December, January, and February).	1.64 inches or 9 percent.
Spring (March, April, and May)	5.69 inches or 31 percent.
Summer (June, July, and August)	8.05 inches or 44 percent.
Fall (September, October, and November).	2.96 inches or 16 percent.
Year (normal)	18.34 inches or 100 percent.

The following records were compiled from the climatological data of the United States Weather Bureau. The actual average of precipitation is given from the time of the beginning of the record at each specific station to the end of the year 1930, except as otherwise noted.

The average annual precipitation at Valentine for the period ending with the year 1930 was 19.55 inches. This is nearly 7 percent greater than the estimated normal of 18.34 inches stated in a preceding paragraph, but if the Valentine record is continued through the year 1936 it will be found that the average annual precipitation has fallen to 18.98 inches.

Precipitation data for the years 1931 to 1936 inclusive have been compiled separately. These years may be described as the "drought years"; while they include brief periods of above normal precipitation, such periods were of insufficient length to bring the annual totals to normal except in isolated areas.

TABLE 1.—*Precipitation, inches and hundredths, for period ending with year 1930*

	Length of record in years	January	February	March	April	May	June	July	August	September	October	November	December	Year
Ainsworth	31	0.59	0.81	1.36	2.29	3.85	3.69	3.17	3.12	1.99	1.50	0.68	0.93	23.98
Alliance	41	.51	.49	.84	2.04	2.80	2.74	2.72	1.78	1.16	1.13	.46	.49	17.16
Gordon	33	.57	.47	.91	2.02	2.87	2.97	2.61	1.75	1.21	1.21	.62	.67	17.88
Halsey	28	.42	.53	.98	2.45	3.46	3.15	3.25	2.99	1.61	1.49	.59	.73	21.65
Kennedy	42	.43	.64	1.00	2.06	2.61	2.37	2.34	1.74	1.12	.95	.47	.58	16.31
Mary	20	.48	.74	1.18	2.50	3.15	3.04	2.89	3.16	1.60	1.74	.63	.74	21.85
Merriman [1]	17	.48	.39	.76	2.36	3.22	3.38	3.48	1.86	1.40	1.38	.78	.46	19.95
Mullen [1]	17	.36	.45	.80	2.37	2.59	2.59	2.61	1.50	1.03	1.09	.21	.35	15.95
Nenzel	15	.57	.43	1.16	2.12	3.12	3.84	3.12	1.91	1.24	1.35	.84	.64	20.34
North Platte	57	.40	.50	.82	2.10	2.84	3.15	2.68	2.42	1.42	1.16	.50	.55	18.54
Purdum	5	.55	.77	1.17	2.46	3.00	3.35	3.13	2.95	1.53	1.44	.72	.82	21.89
Valentine	42	.57	.55	1.22	2.21	2.75	3.06	2.94	2.44	1.34	1.21	.66	.60	19.55
Whitman	22	.33	.43	1.04	1.84	2.71	2.76	2.79	1.80	.91	.82	.43	.48	16.34

[1] Number of years record as indicated but years not consecutive.

Although each of the six years designated as "drought years" was dry, the most devastating droughts occurred in 1934 and 1936. The year 1930 was severely dry in much of the Middle West, but had above normal precipitation in the sandhills and is not included with the "drought years" in this discussion. The year 1937 is likewise a drought year but cannot be included, as its data have not yet been compiled.

TABLE 2.—*Precipitation: the drought years, 1931–36 inclusive*

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Ainsworth	0.44	0.78	1.24	2.00	2.98	2.51	1.42	2.28	1.65	0.57	0.39	0.50	16.86
Alliance	.18	.52	.82	2.66	2.10	1.82	1.12	2.04	.69	.38	.35	.40	13.18
Gordon	.38	.43	1.34	2.01	1.92	2.24	1.85	2.15	.69	.52	.44	.53	14.51
Halsey	.23	.48	.89	2.08	3.03	2.50	2.06	3.00	1.88	.43	.29	.83	17.29
Mary	.32	.76	1.13	2.06	4.56	3.17	2.07	1.98	1.37	.60	.43	.53	18.98
Merriman	.42	.52	1.40	2.03	2.60	2.22	1.84	1.79	.75	.72	.55	.50	15.34
Nenzel	.48	.67	1.52	2.05	2.40	2.60	1.90	2.46	.82	.64	.56	.58	16.93
North Platte	.22	.42	.74	2.35	2.38	2.41	1.92	2.06	1.22	.38	.29	.43	14.82
Purdum	.45	.98	2.04	2.36	3.48	2.25	1.79	2.56	1.67	.47	.43	.81	19.06
Valentine	.34	.49	1.57	1.95	2.61	2.31	1.71	1.34	.73	.64	.29	.36	14.87

Table 3 is a composite of tables 1 and 2. Only 10 stations are used: Ainsworth, Alliance, Gordon, Halsey, Mary, Merriman, Nenzel, North Platte, Purdum, and Valentine, in order that the data might be comparable. The table shows the mean precipitation for these stations for (1) the years ending with 1930, (2) the "drought years," 1931 to 1936 inclusive, and (3) the percent of change during the "drought years" as compared with the preceding period.

TABLE 3

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Years ending with 1930	0.51	0.57	1.04	2.26	3.11	3.24	3.00	2.44	1.45	1.36	0.65	0.66	20.28
Drought years 1931–36 inclusive	.35	.60	1.27	2.16	2.18	2.40	1.77	2.17	1.15	.54	.40	.55	16.18
Percent of change	−31	+5	+22	−4	−10	−26	−44	−11	−20	−60	−40	−17	−20

A study of table 3 shows that during the "drought years" there has been a sharp drop in the midsummer and fall precipitation. The average for June 1931–36 inclusive, dropped 26 percent below the average for June for the years ending with 1930. There was a similar drop of 44 percent in July. Inasmuch as June and July are critical months for corn, there has been no corn crop worthy of the name during the drought years. Yet there have been good hay crops at least 3 years out of the 6, as early spring rains have given the grass a good start before the excessively hot dry weather began. The spring of 1935 was wet, and there was a bountiful hay crop. Good rains likewise fell early in 1933 and 1932, and there were good hay crops during these years, but little corn. The years 1934 and 1936 were extremely dry from early spring to late fall.

Table 3 also reveals a sharp drop in the fall precipitation: a decrease of 20 percent in September, 60 percent in October, and 40 percent in November. Dry weather in the fall has favored duststorms and destroyed winter wheat.

Rainfall is the most variable of meteorological elements; table 4 shows the extremes of record at Valentine for the years 1889 to 1936 inclusive. These data are based on the calendar year. The driest 12 months of record began with September 1933 and ended with August 1934. During this period only 8.78 inches fell.

TABLE 4

	January	February	March	April	May	June	July	August	September	October	November	December	Year
Wettest	1.61	1.55	2.87	7.03	8.18	8.18	7.97	5.02	4.06	4.81	2.74	1.56	28.91
Driest	.04	.04	.16	.12	.17	.32	.04	.33	.08	.00	.01	.03	10.14

A discussion of precipitation in the sandhills area would not be complete without mention of blizzards, thunderstorms, and hail.

The blizzard does not occur as frequently as the public assumes. One of the worst storms of record in the sandhills area was in March 1913; no trains came into Valentine for 5 days. Old timers still talk about the frightful blizzard of 1888. However, such visitations of subzero cold, high wind and heavy snow are fortunately rare. The heaviest snows are most likely to occur in November, March, or even April. On the average, March is the month of heaviest snowfall in central and eastern portions of the sandhills; but farther west, where the altitude is higher and spring more retarded, April is often the month of heaviest snow. The average annual snowfall in the sandhills ranges from approximately 30 to 50 inches, the smaller amounts falling in southern portions along the Platte River.

During the warmer months thunderstorms are frequent. Many small showers, local in character and the result of local conditions, fall in the sandhills. The heavy deluges that sometimes occur are connected with the advance of a cold front and widespread thunderstorms. At Valentine the total number of days with 1.00 inch or more of precipitation for the years 1889 to 1936, inclusive, is as follows: January, 0; February, 0; March, 4; April, 15; May, 22; June, 25; July, 35; August, 21; September, 8; October, 11; November, 2; and December, 0. The greatest precipitation ever recorded in 5 minutes by tipping bucket is 0.80 inch; in 10 minutes, 1.41 inches; in 15 minutes, 1.72 inches; in 30 minutes, 2.51 inches; in 1 hour, 3.02 inches; in 24 hours, 4.21 inches.

Except when snow falls, or during heavy rains of early spring, precipitation of 1 inch or more usually occurs in connection with thunderstorms. Heavy hail falls occasionally, sometimes even mowing the grass, but hail damage in the sandhills is not as great as in more densely populated and agricultural regions.

Evaporation is high in the sandhills area. Hot summer days, brisk wind movement, and low humidity are highly effective for rapid evaporation of moisture, wherever found. No evaporation (data) actually in the sandhills are available, but a record at North Platte has been used in the the compilation of table 5. The data in this table are for the period beginning with the spring of 1927 and continued through the season of 1936, and include, (1) the average monthly evaporation for the period ending with the year 1930 (the April average is for 1928, 1929, and 1930 only); (2) the average monthly precipitation for the "drought years," 1931 to 1936, inclusive; (3) the percent of change in the rate of evaporation during the "drought years" as compared with the rate during the preceding period.

TABLE 5.—*Evaporation in inches and thousandths*

	April	May	June	July	August	September
1927–30, inclusive	5.509	6.211	5.943	8.909	7.878	6.949
1931–36, inclusive	5.464	6.707	8.411	10.714	8.393	6.431
Percentage of change	−1	+8	+42	+20	+7	−7

The years 1927 and 1928 were slightly above normal in precipitation at North Platte; 1929–30, considerably above normal; 1931–34, below normal; 1935 again slightly above, and 1936 decidedly below normal. The data show that in dry years, when there is less water to evaporate, the potential evaporation is much higher.

The sandhills area is outside the eastern zone of heavy precipitation. "Dry storms," that is, low-pressure areas without any precipitation, often cross the sandhills. When a LOW comes from the northwest it may be followed by cold, or by a duststorm, or both, but it seldom brings precipitation to the sandhills area. When precipitation does fall during the passing of such a LOW, it is usually light. Heavy precipitation in the sandhills almost always comes from a Colorado LOW, or one located somewhat to the east of Colorado. In other words, a LOW coming from the southwest, or south-southwest, brings the heaviest precipitation to the Nebraska sandhills.

During the past few years southwestern LOWS have been fewer than usual, and their occurrence did not always bring precipitation. However, there is no scientific reason for believing that the "drought years" constitute a permanent change in climate. Doubtless the future will again bring more rain to the sandhills, and their recuperative power is amazing.

LITERATURE CITED

Condra, George E. Geography, Agriculture, Industries of Nebraska. Lincoln, Nebr. 1934.

Fenneman, Nevin M. Physiography of western United States. New York. 1931.